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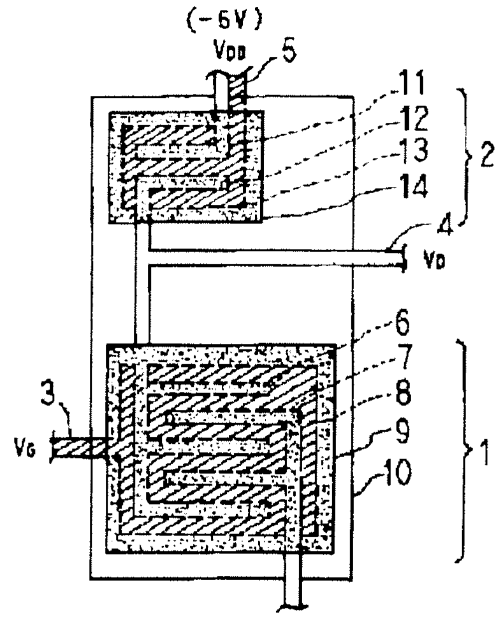
TITLE : INVERTER



ABSTRACT : PURPOSE: To make an inexpensive inverter at high integration degree on a large-area board by constituting an active layer of at least one side of a switching element and a load element out of an organic compound having semiconductor properties.

CONSTITUTION: For an active layer 9, anything will do so long as it may be an organic compound which has semiconductor characteristics, for example it can be made of a charge transfer complex or the like (or the combination of these compounds) of each kind of low polymer or high polymer of a kind of polyphyline, a kind of metallic polyphiline, a kind of metallic phthalocyanine, or the like. As the method of making the active layer 9 consisting of an organic semiconductor, vacuum deposition method, molecular beam epitaxial growth method, ion cluster beam method, or the like is select according to the material. Next, similar to a switching element 1, the basic structure of the load element 2, where the active layer 14 is constituted of an organic semiconductor film, is the same as the switching element 1. Hereby, an inverter wide in application range can be gotten, using a semiconductor which is simple in process and inexpensive.

CLAIMS

[Claim(s)]
[Claim 1]In an inverter of a switching element or the load elements used as said switching element at least a field effect transistor characterized by comprising the following, An inverter constituting at least one active layer of said switching element or said load elements from an organic compound which has a semiconductor characteristic.
A gate electrode.
A source electrode and a drain electrode which have been arranged so that said gate electrode may be countered.
An active layer for forming a current path between said source electrode and said drain electrode.

[Translation done.]

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the inverter using the organic compound (henceforth an organic semiconductor) which has a semiconductor characteristic especially as an active layer about the inverter used for a logic gate, a memory IC, a switching element or an amplifier, IC that makes these a basic constitution element, etc.
[0002]
[Description of the Prior Art]Generally, since an organic semiconductor has the strong point in which it is cheap, lightweight compared with an inorganic semiconductor, and is rich in moldability, and simplification of a process can be measured, it is attracting attention especially in recent years. pi-conjugated system polymers which are conventionally represented by the low molecule semiconductor represented by phthalocyanine and the polythiophene as an organic semiconductor, Or although a skeleton is the same as pi-conjugated system polymers, many things which show semiconductor character, such as pi-conjugated system oligomer which is represented by thiophene oligomer with the small number of repeating units, are known.
[0003]It is thought that these organic semiconductors form the band structure which consists of a forbidden band which separates a valence band, a conducting zone, and these like an inorganic semiconductor, It is explained by by deducting an electron from a valence band or pouring an electron into (oxidation) and a conducting zone using the chemical method, an electrochemical process, or a physical method (doping) (reduction) that the career which carries an electric charge is produced. From such semiconductor character, an organic semiconductor can be applied to various semiconductor devices, and some reports are made until now.
[0004]Specifically The 52nd volume of "journal OBU applied physics (J. Appl.Phys.), The Schottky barrier element using the polyacethylene referred to at the 869th page, 1981", JP,56-147486,A, etc., The Schottky barrier element using the polypyrrole system polymers referred to at "the 54th volume of journal OBU applied physics (J. Appl.Phys.), the 2511st page and 1983", JP,59-63760,A, etc. is known. The hetero-junction element which combined the n-mold CdS and p-mold polyacethylene which are inorganic semiconductors is reported so that it may be referred to in "the 51st volume of journal OBU applied physics (J. Appl.Phys.), the 4252nd page, and 1980."
[0005]As a junction element which combined organic semiconductors, "applied physics Letters (Appl.Phys.Lett.) -- the 59th volume, p-mold referred to in the 1279th page and 1985", and pn homo junction element using n-mold polyacethylene, moreover -- "-- the 24th volume of the Japan journal OBU applied physics (Jpn.J.Appl.Phys.), and the Lth -- the hetero-junction element which consists of the polypyrrole and the polythiophene which are referred to at 533 pages and 1985" is also known.
[0006]. These days, the trial which applies an organic semiconductor to the active layer of a field effect transistor (FET) should do. "The 54th volume of journal OBU applied physics (J. Appl.Phys.),The 3255th page, the thing using the polyacethylene referred to in 1983", "-- chemistry Letters (Chem.Lett.) -- the thing using the poly (N-methylpyrrole) referred to at the 863rd page and 1986"."applied physics Letters (Appl.Phys.Lett.) -- the 49th volume,The 1210th page,

the thing using the polythiophene referred to in 1986", "-- chemical physics Letters (Chmi.Phys.Lett.) -- the thing using the metal phthalocyanines referred to at the 142nd volume, the 103rd page, and 1987". Or the thing using the thiophene oligomer referred to in "the 72nd volume of solid-state communication (Solid State Comm.), the 381st page, and 1989", etc. are known.

[0007]Such FET uses inorganic semiconductors, such as Si and GaAs, for an active layer, and practical use is presented with it.
It is used as a semiconductor device, and also [individual] setting up was finished as an IC element and the variegated function is realized.
However, on the other hand, the report of those other than the above-mentioned individual transistor is not made at all, but since chisel realization is individual and possible, a function is restricted, and as for the transistor which used the organic semiconductor for the active layer, application is limited extremely. Therefore, the inverter used as basic constitution elements, such as a logic gate, a memory IC, a switching element, and an amplifier, is unrealizable.
[0008]
[Problem(s) to be Solved by the Invention]Since the semiconductor device which used the conventional organic semiconductor for the active layer was realized only as an individual transistor as mentioned above, the function was restricted and there was a problem that application was limited.
[0009]It was made in order that this invention might solve the above problems, and a process aims at obtaining the large inverter of the application range used as the basic constitution element of various IC circuits using an easy and cheap organic semiconductor.
[0010]
[Means for Solving the Problem]An inverter concerning this invention constitutes at least one active layer of a switching element or the load elements from an organic semiconductor.
[0011]
[Function]In this invention, a cheap inverter is created with a large degree of location on a large area substrate using an organic semiconductor with the sufficient process efficiency as an active layer.
[0012]
[Example]Hereafter, one example of this invention is described about a figure. The top view in which drawing 1 shows one example of this invention, the circuit diagram in which drawing 2 shows the inverter of drawing 1, and drawing 3 are the sectional views showing the structure of the switching element in drawing 1 concretely. Here, the inverter of the saturation IGFET which consists of insulated-gate type FET (IGFET), and the load IGFET is shown as an example of an inverter.
[0013]In drawing 1 - 3, they are a switching element to which 1 performs a switching action, and a load element which the series connection of 2 is carried out to the switching element 1, and acts as load (nonlinear resistance element). In this case, the switching element 1 and the load element 2 are FET of an identical configuration mostly.
One inverter is constituted in great numbers.
The load element 2 may be the usual linear-resistance machine, as mentioned later. It is the constant-voltage terminal by which connects 3 to the input terminal of an inverter, 4 was connected to the output terminal of an inverter, and 5 was connected to power supply V_{DD}.
[0014]6, 7, and 8 are a drain electrode of the switching element 1, a source electrode, and a gate electrode, respectively, the drain electrode 6 and the source electrode 7 have a gap mutually, and the placed opposite is carried out to the gate electrode 8. The drain electrode 6 is connected to the output terminal 4, the source electrode 7 is connected to a ground, and the gate electrode 8 is connected to the input terminal 3.
[0015]Generally as the gate electrode 8, gold, platinum, chromium, palladium, Although metal, such as aluminum, indium, molybdenum, low resistance polysilicon, and a low resistance amorphous silicon, a stannic acid ghost, indium oxide, an indium stannic acid ghost (ITO) (or such materials should put together), etc. are used, It is not necessarily restricted to such materials and a

conductive organic system low molecular weight compound and pi-conjugated system polymers may be used.

[0016]9 is an active layer which forms a current path between the drain electrode 6 of the switching element 1, and the source electrode 7, and comprises a thin film of the organic semiconductor. The active layer 9 of the organic semiconductor has covered the gate dielectric film (it mentions later) located between the drain electrode 6 and the source electrode 7 with the drain electrode 6 and the source electrode 7.

[0017]If the active layer 9 is an organic compound which has semiconductor character, it is [anything] good, For example, porphyrins, metalloporphyrins, and phthalocyanines, It may be formed from the electron donor acceptor complex (or these compounds should put together) etc. of the various low molecules represented with low molecule organic semiconductors, such as metal phthalocyanines and merocyanine, and a tetrathiafulvalene tetracyano quinodimethane (TTF-TCNQ) complex, and polymers.

[0018]As other usable polymer materials, to the active layer 9, Polyacethylene, polypyrrole, poly (N-substitution pyrrole), poly (3-substitution pyrrole), Poly (3,4-2 substitution pyrrole), a polythiophene, poly (3-substituted thiophene), Poly (3,4-2 substituted thiophene), poly benzothiophene, polyisothianaphthene, Poly (2, 5-thienylene vinylene), a poly (2, 5-thienylene vinylene) derivative, Poly (2, 5-FURIREN vinylene), a poly (2, 5-FURIREN vinylene) derivative, Poly aniline, poly (N-substituted aniline), poly (2-substituted aniline), Poly (3-substituted aniline), poly (2,3-2 substituted aniline), and polydiacetylene. There are a polyazulene, polypyrene, polycarbazole, poly (N-substitution carbazole), polyseleno Foehn, a polyfranc, polybenzofuran, poly para-phenylene, poly para-phenylene vinylene, a polyindole, pyridazine, poly acene, graphite-like polymers, etc. It is usable also in pi-conjugated system polymers, such as two or more kinds of copolymers of these polymers, and these amphiphilic derivatives, and there is no restriction in the number of repeating units of the polymers, and it is usable also in four or more oligomer with a number of repeating units.

[0019]10 is gate dielectric film with which between the drain electrode 6 and the source electrode 7, and the gate electrodes 8 is insulated, In an inorganic system or an organic system, ****, silicon oxide, silicon nitride, an aluminum oxide, It may be formed from polyethylene, polyester, polyimide, a polyphenylene sulfide, poly paraxylene, polyacrylonitrile, or various insulating LB film (or such materials should put together).

[0020]11, 12, and 13 are a drain electrode of the load element 2, a source electrode, and a gate electrode, respectively, the drain electrode 11 and the source electrode 12 have a gap mutually, and the placed opposite is carried out to the gate electrode 13. The drain electrode 11 is connected to the constant-voltage terminal 5, the source electrode 12 is connected to the output terminal 4, and the gate electrode 13 is connected to the constant-voltage terminal 5. 14 is an active layer which consists of a thin film of the organic semiconductor which forms a current path between the drain electrode 11 of the load element 2, and the source electrode 12, and has covered the gate dielectric film 10 located between the drain electrode 11 and the source electrode 12 with the drain electrode 11 and the source electrode 12. Between the drain electrode 11 and the source electrode 12, and the gate electrodes 13 has insulated the gate dielectric film 10.

[0021]15 is an insulating substrate in which the gate electrode 8 is formed, and may comprise various insulating plastics, such as glass, an alumina sintered body, a polyimide film, polyester film, a polyethylene film, a polyphenylene sulfide film, and a poly paraxylene film.

[0022]Next, the concrete preparation method of the switching element 1 which constituted the active layer 9 from an organic semiconductor thin film is explained individually, referring to drawing 3. This kind of switching element 1 is applicable to FET, such as IGFET, junction-gate type FET, and Schottky gate type FET. The time of element creation applying to easy IGFET especially among these FET is the optimal, and the case where the switching element 1 is IGFET is shown here.

[0023]The switching element 1 shown in drawing 3 is not restricted to this structure in particular, although the active layer 9 of an organic compound has the plena structure where it is located on the drain electrode 6, the source electrode 7, and the gate electrode 8. For example,

the drain electrode 6 and the source electrode 7 may adopt the stagger structure where it is located on the active layer 9, as element structure of such IGFET, or the reverse stagger structure where the gate dielectric film 10 is located on the active layer 9, and the gate electrode 8 is further located on it may be adopted. The reverse plena structure where the active layer 9 is located on the insulating substrate 15, the drain electrode 6 and the source electrode 7 are located on it, and also the gate electrode 8 is located via the gate dielectric film 10 on the active layer 9 between the drain electrode 6 and the source electrode 7 etc. may be adopted.

[0024]In drawing 3, first, form the gate electrode 8 on the insulating substrate 15, and the gate dielectric film 10 is formed on the gate electrode 8, The electrode 6, i.e., the drain electrode, and the source electrode 7 of a couple which were isolated about the predetermined gap are formed on the gate dielectric film 10, and the active layer 9 which consists of organic semiconductors is further formed between the drain electrode 6 and the source electrode 7.

[0025]At this time, formation methods of the metal membrane 8, i.e., a gate electrode, include vacuum evaporation, sputtering, plating, various CVD growth, etc. The gate electrode 8 may serve both as the gate electrode 8 and the insulating substrate 15 according to the purpose of use, and conductive plates, such as a silicon wafer, a stainless plate, and a copperplate, may be used for it. When serving both as the gate electrode 8 and the insulating substrate 15 with a silicon wafer, it is preferred to use the silicon oxide film obtained by the thermal oxidation method of silicon, etc. as the gate dielectric film 10.

[0026]As a thin film creating method of the active layer 9 which consists of organic semiconductors, A vacuum deposition method, molecular beam epitaxy, the ion cluster beam method, The low energy ion beam method, the ion plating method, a CVD method, sputtering process, the plasma polymerizing method, an electrolytic polymerization method, a chemical polymerization method, a spin coat method, the cast method, a dipping method, the roll coat method, the bar coat method, the LB method, etc. may be chosen according to those with usable, and material. As for especially the thickness of this active layer 9, generally, although it is not restricted but changes also with organic semiconductors, 3000A or less is desirable in order to influence the characteristic of the switching element 1 greatly in many cases.

[0027]Although the electrical property of an organic semiconductor is often controlled by doping processing, as this doping method, there are the chemical method and a physical method and it is usable in all. The chemical methods include doping from (1) gaseous phase, doping from (2) liquid phase, (3) electrochemical doping, (4) light start doping, etc., and there is ion implantation in a physical method.

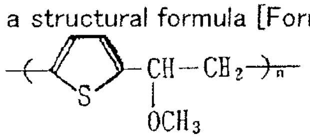
[0028]Although there is no restriction in particular as a formation method of the gate dielectric film 10, a CVD method, plasma CVD method, the plasma polymerizing method, vacuum deposition, the spin coating method, a dipping method, an ionized-cluster-beam-evaporation method, the LB method, etc. are used, for example.

[0029]Next, the method of creating the load element 2 the active layer 14 comprised an organic semiconductor thin film is explained like the switching element 1. If the essential structure of the load element 2 is the same as that of the switching element 1 shown in drawing 3, for example, the case of IGFET is explained, The gate electrode 13 is formed on the insulating substrate 15, the electrode 11, i.e., the drain electrode, and the source electrode 12 of a couple which were isolated about the predetermined gap via the gate dielectric film 10 are formed on it, and the active layer 14 is formed between the drain electrode 11 on it, and the source electrode 12. It is not restricted to plena structure, but stagger structure, reverse stagger structure, reverse plena structure, etc. are created arbitrarily, and an element material, the disposal method also of the load element 2, etc. are the same as that of the case of the switching element 1.

[0030]In drawing 1 and drawing 2, although the load element 2 (or that structure) was used as the saturated type which connected the drain electrode 11 to the gate electrode 13, it is not necessarily restricted to this structure. For example, the source electrode 12 may be connected to the gate electrode 13 like drawing 4 as another saturated type structure. The switching element 1 is an enhancement n channel, and, in the depression type which is a depression n channel, the load element 2 is preferred for the structure of drawing 4.

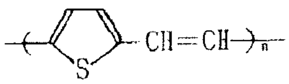
[0031]Like drawing 5, it is usable and the unsaturation form which made the drain electrode 11, the source electrode 12, and the gate electrode 13 become independent altogether also needs to form the gate terminal 16 independently in this case for the gate electrode 13 of the load element 2. The planar structure of an inverter becomes like drawing 6, and the gate electrode 13 is thoroughly isolated from the constant-voltage terminal 5. It is good also as a complementary which reversed the polarity of power-supply-voltage V_{DD} and connected each gate electrodes 8 and 13 of the switching element 1 and the load element 2 like drawing 7. The switching element 1 is an enhancement n channel, and this structure is preferred when the load element 2 is a depression form p channel.
[0032]Although the organic semiconductor used as each active layers 9 and 14 of the switching element 1 and the load element 2 was individually formed in drawing 1, it can also form at once with one kind of organic semiconductor, and, thereby, an element creation process can be simplified further.
[0033]Although both the active layers 9 and 14 of each FET were constituted from an organic semiconductor, what is necessary is just to constitute at least one active layer of the switching element 1 or the load element 2 from an organic semiconductor, and another side can also consist of inorganic semiconductors. For example, inorganic semiconductor FET with III-V fellows compounds, such as an amorphous silicon, single crystal silicon, polycrystalline silicon, and GaAs, can be used as the switching element 1.
[0034]It may replace with the load element 2 which consists of IGFET(s), and the usual linear-resistance machine 17 may be used like drawing 8. In this case, as a method which the restriction in particular about the linear-resistance machine 17 does not have, and forms the linear-resistance machine 17 on the same insulating substrate, it is usable in an impurity diffusion method, ion implantation, a polycrystalline silicon grown method, etc. [as opposed to a high resistance insulator for example,] As each elements 1 and 2, as mentioned above, it is usable and the restriction about element structure does not have Schottky gate type either [not only IGFET but] junction-gate type FET or FET etc., either.
[0035]Next, the case of drawing 8 is taken for an example for simplification, and operation of the inverter by this invention is explained. Here, the case where p channel IGFET which operates by the enhancement mode which current I_D increases according to gate impressed-electromotive-force V_G is used as the switching element 1 is explained.
[0036]If input voltage V_{IN} (=V_G) is impressed and gate voltage V_G is impressed to the gate electrode 8, it is generated by the career in the active layer 9, and the switching element 1 will be in a flow (one) state, and current I_D will flow through it into the drain electrode 6 from the source electrode 7. Since it is not generated by the career in the active layer 9 when input voltage V_{IN} (=V_G) is not impressed, current I_D will not flow between the source electrode 7 and the drain electrode 6, but the switching element 1 will be in an OFF state.
[0037]Therefore, where power-supply-voltage V_{DD} is impressed to the constant-voltage terminal 5, when input voltage V_{IN} is not impressed to the input terminal 3, The switching element 1 serves as OFF, and current I_D of an inverter circuit does not arise, but output voltage V_{OUT} (=V_D) almost equal to power-supply-voltage V_{DD} is obtained from the output terminal 4. [0038]On the other hand, if input voltage V_{IN} is impressed to the input terminal 3, the switching element 1 will be in an ON state, current I_D will arise, and it will flow into the linear-resistance machine 17 as the load element 2. By this current I_D, a voltage drop arises in the linear-resistance machine 17, and output voltage V_{OUT} becomes low by that voltage drop. At this time, the relation between input voltage V_{IN} and output voltage V_{OUT} is shown like drawing 9. Here, power-supply-voltage V_{DD} is set to -5V, and when changing input voltage V_{IN} in 0V - -5V, the output swing of output voltage V_{OUT} which was illustrated can be obtained.

[0039]Next, other examples adapting the inverter by this invention are described. Drawing 10 is a circuit diagram showing the ring oscillator which connected the odd same inverters as drawing 2, the output terminal 4 of the inverter of an input side is connected to the input terminal 3 of a latter inverter, and shares the constant-voltage terminal 5, and is arranged by series one by one. 18 is a constant-voltage terminal by the side of sauce, and is connected to each inverter in common. Although the number of stages of the inverter was set to 5, it can be set as arbitrary odd number number of stageses. For example, when power-supply-voltage V_{DD} and input voltage V_G were set to -5V and the number of inverter stages was made into 11 steps, respectively, the oscillation was accepted by the voltage monitor and it was called for at the room temperature that the signal transduction speed per gate is 1microsec.
[0040]In the case of a ring oscillator, the structure and the creating method of each element are the same as that of the above-mentioned, but since it comprises many inverters, it is preferred to use the creating method which can form many inverters at once. For this reason, wet process, such as vacuum processes, such as a vacuum deposition method, an ionized-cluster-beam-evaporation method, organic molecular beam epitaxy, and an organic molecular-beam-deposition method, or the spin code method, a dipping method, the cast method, the roll coat method, and the bar code method, is preferred. As for the active layer of each switching element 1 in a ring oscillator, and the load element 2, forming with a single organic semiconductor is preferred.
[0041]Next, the formation process of the inverter by this invention is explained in detail, referring to drawing 3. First, usual vacuum deposition, optical lithography method, and etching method are used on this wafer, for example at 2 cm in diameter, using a 0.7-mm-thick non-alkali glass wafer as the insulating substrate 15, and a chrome thin film pattern with a thickness [used as the gate electrode 8] of 1000 A is formed.
[0042]Then, after using usual vacuum deposition and mask method, forming SiOx with a thickness [used as the gate dielectric film 10] of 5000 A on the gate electrode 8, and also using vacuum deposition and forming a 1000-A-thick chrome thin film on it, a 2000-A-thick metal membrane is formed on it. Here, the chrome thin film of the ground is used in order to raise adhesion with the gate dielectric film 10 (SiOx), the substantial drain electrode 6, and the source electrode 7 (metal membrane). Next, the metal membrane which uses a chrome thin film as a ground is patterned using a usual optical lithography method and etching method, the desired drain electrode 6 and the source electrode 7 are formed, and it is considered as an element substrate.
[0043]Next, the process of forming the active layer 9 on an element substrate is explained. First, a structural formula [Formula 1]



(n ≒ 1000)

It comes out and the spin coat of the 2wt% dimethylformamide solution of this precursor polymer is carried out on an element substrate using the poly (2,5-thienylene vinylene) precursor shown. Number of rotations performs turnover time at 4000 rpm, it is performed in 60 seconds, and, as for the spin coat at this time, ambient temperature is performed in the air at 60 **, for example.
[0044]In this way, after making it dry enough to the thin film of the formed precursor polymer, heat-treatment for 90 minutes is performed at 210 ** under the nitrogen air current containing a little hydrogen chloride gas using an infrared gold image furnace. Supply of the hydrogen chloride gas at this time slushes nitrogen gas on the chloride reagent undiluted solution in a scrubbing bottle, and after drying the nitrogen gas containing the hydrogen chloride gas which flows out of a scrubbing bottle with concentrated sulfuric acid and a calcium chloride drying tube, it is performed by flowing in an image furnace.
[0045]By this heat-treatment, a poly (2,5-thienylene vinylene) precursor polymer is a structural formula. [Formula 2]



($n \fallingdotseq 1000$)

It comes out, is changed into the poly (2,5-thienylene vinylene) shown, and becomes a very homogeneous brown film which has gloss. In the infrared absorption spectrum of the thin film after heat-treatment the check of this conversion, Absorption of the C-O-C stretching vibration of 1100-cm^{-1} based on the side chain ether bond of a precursor polymer disappears, It can carry out, when absorption of the deformation vibration outside a transformer BIMINIREN C-H side of 1590-cm^{-1} based on a poly (2,5-thienylene vinylene) vinylene combination appears. Or in an electron spectrum, the absorption based on a pi-pi star (state which the conductive electronic state reversed by the optical exposure etc.) with the about 530-nm maximum appears, and the above-mentioned conversion can be checked also from pi-conjugated bond by repetition of a single bond and a double bond being formed.

[0046]In this way, the obtained inverter comprises plena type IGFET so that it may be referred to at drawing 1 - drawing 3, The chrome thin film between a glass wafer element substrate (insulating substrate 15) and a SiOx insulator layer (gate dielectric film 10) works as the gate electrode 8, and the metal membrane of the couple which uses the chrome thin film on the gate dielectric film 10 as a ground works as the drain electrode 6 and the source electrode 7. Even if it does not perform doping processing at all, poly (2,5-thienylene vinylene), i.e., PTV, which are polymers of pi-conjugated system, it shows a semiconductor characteristic, and it works as the active layers 9 and 14 of the switching element 1 and the load element 2.

[0047]Here, the channel width (W) and channel length (L) of the switching element 1 are 2 mm and 2.5 micrometers, respectively.

The channel width (W) and channel length (L) of the load element 2 are 400 micrometers and 2.5 micrometers, respectively.

Drawing 11 shows the electrical property of the switching element 1 obtained in this way, a horizontal axis is voltage V_{DS} between the source electrode 7 and the drain electrode 6, and a vertical axis is current I_D between the source electrode 7 and the drain electrode 6. threshold voltage V_{TH} in case each static characteristic in different gate voltage V_G (=-1v, -2v, --, -5V) is shown here and a channel begins to be formed in the active layer 9 from this static characteristic -- about -- it is 0V. And it is called for that carrier mobility mu is $1\times10^{-1}\text{cm}^2/\text{v-sec}$.

[0048]On the other hand, in order to use the load element 2 as the saturation load element (drawing 2) which consists of IGFET(s), the drain electrode 11 (isolated from the gate electrode 13 via the gate dielectric film 10) in which power-supply-voltage V_{DD} is impressed is connected with the gate electrode 13 on the outside of the load element 2. Thereby, it becomes $V_{DD}=V_{GG}$ and, ideally, the current value at the current saturation start time by the pinch-off in transistor characteristics comes to be shown. The load line of such a saturation load element 2 is shown in drawing 11. Here, a horizontal axis is, gate voltage V_{GG}, i.e., power-supply-voltage V_{DD}, of the load element 2. The input-output behavioral characteristics of the inverter combined with the switching element 1 become like drawing 9, as mentioned above.

[0049]As mentioned above, although the load element 2 was explained as a saturation load element, in drawing 5 and an unsaturation load element like drawing 6 as well as the above, it can create. In this case, power-supply-voltage V_{DD} and gate voltage V_{GG} are not necessarily in agreement, and the channel resistance value of the load element 2 is arbitrarily set up by gate voltage V_{GG}. However, as mentioned above, since gate threshold voltage V_{TH} is 0V mostly, When gate voltage V_{GG} is coincided with power-supply-voltage V_{DD} and it uses in the current saturation field of the load element 2, in accordance with the characteristic in the case of the

above-mentioned saturation load element, the input-output behavioral characteristics of an inverter also become being the same as that of drawing 9.

[0050]As mentioned above, an organic inverter element can be used as an inverter used as basic building blocks, such as an IC circuit, by creating to a monolithic what combined two organic FET (or at least one piece) combining creation, or organic FET and a linear-resistance machine. Therefore, rather than before, can create an element on a large area substrate in an easy process, and a degree of location improves, and also cost is reduced. At this time, output voltage V_{OUT} of reverse voltage is obtained to input voltage V_{IN}, and inverter characteristics are not spoiled.The ring oscillator of structure which connected odd same inverters is also can be created.

[0051]

[Effect of the Invention]The organic semiconductor constituted at least one active layer of a switching element or the load elements from this invention as mentioned above.
Therefore, it is effective in the large inverter of the application range where a process serves as a basic constitution element of various IC circuits using an easy and cheap organic semiconductor being obtained.

[Translation done.]